

## Improved Hydrogen Supply Could Increase Annual Revenues by \$30+ million

### Methodology

Upgrade Performance Study of an existing facility

### 50 Words or Less

Our client produces make-up hydrogen required for a hydrocracker unit by gasifying asphaltenes. Because gasifiers are notoriously unreliable, our client performed an Upgrade study of this facility and learned that building a 50% redundant hydrogen supply would maximize return on investment and could improve average annual revenues by \$37 million.

### Project Background

Our client, a Canadian energy company, has a facility in Alberta to recover and upgrade oil-sands (bitumen) reserves. Pivotal to their existing facility is the Hydrocracking (HCR) Unit which uses hydrogen, heat and catalyst to upgrade longer hydrocarbon molecules (bitumen) into shorter molecules (Premium Synthetic Crude), which are then pumped to a pipeline for sale at roughly the WTI (West Texas Intermediate) spot price for crude.

The stickiest, heaviest portion of the bitumen, the asphaltenes, are too thick and cannot be transformed into the Premium Synthetic Crude. Instead, this facility uses these asphaltenes as fuel for a gasification process that breaks down the asphaltenes into hydrogen and carbon monoxide in the presence of sub-stoichiometric oxygen, high temperatures and catalyst. This process converts what would otherwise be a low-value byproduct into something with a much higher value, make-up hydrogen for the hydrocracker.

However, to maximize production (and therefore profits) the Upgrader plant



Even a Hydrogen Plant that only adds 25% more hydrogen could significantly improve revenue

needs a consistent and continuous input stream of make-up hydrogen to replace the hydrogen consumed by the process. Any reduction in make-up hydrogen roughly translates to a roughly equivalent reduction in hydrocracker production. Unfortunately, gasifiers are not highly reliable, so frequent and lengthy gasifier outages substantially reduce hydrocracker production and therefore profits.

### The Problem

When deciding which capital investment project to pursue, the goal is to select the project that will net the highest return on investment. The problem is that in most industry pro formas, all assumptions for revenue improvements are based on either:

- Tribal knowledge (guessing)
- Single-point improvements (ignoring system effects)

Simulation provides an effective means to empirically evaluate plant perfor-

mance to both improve confidence and reduce risk. Outside of our Upgrade methodology, however, there isn't a unified simulation method to both properly and empirically account for all of the complexity of the real world when evaluating plant performance.

With Upgrade, our client knows they're making the best possible capital allocation decision because they have the empirical evidence to back it up

### Study Objectives

The natural goal of this study is to determine how additional hydrogen supply would affect revenue. Specifically, the objectives of this study were to identify the average improvement in revenue with the addition of:

- 25% excess hydrogen supply
- 50% excess hydrogen supply
- 75% excess hydrogen supply
- 100% excess hydrogen supply

Where 100% hydrogen supply is the normal hydrocracker make-up rate.

## Case Study: Hydrogen Supply (cont')

### System Description

Figure 1 below is a simplified Block Flow Diagram (BFD) of the modeled system. Though the actual model includes many more elements than are shown here, including upstream bitumen recovery units and certain utility or support units, this figure represents the configuration of the critical units in the system.

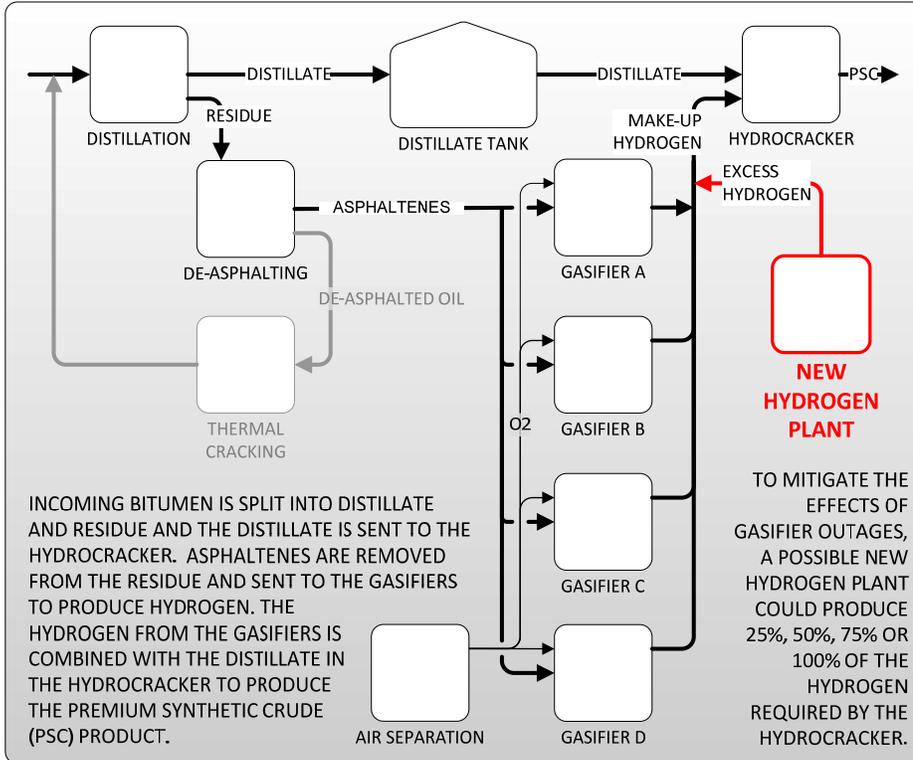


Figure 1 – A simplified Block Flow Diagram of the facility with new capital in red

### Failure Data

With all reliability-based studies, good failure data is fundamental to providing meaningful results. As the adage goes, garbage in: garbage out. For all Upgrade studies, we prefer to use actual operational data, but when that data is not available (as with a not-yet-built Hydrogen plant), we use a combination of trusted failure data sources from industry and vendor databases.

Regardless, all data undergoes a thorough vetting process with the project team before it is used in any study.

### Existing Model = Quick Results

Generating the results for the objectives took only a few days because a model of the existing facility was already fully developed when our client asked us to perform this study (see the related Case Study: Oil Sands Plant Infrastructure). This is a notable benefit to Upgrade Performance Studies. Once the work to develop a baseline model is

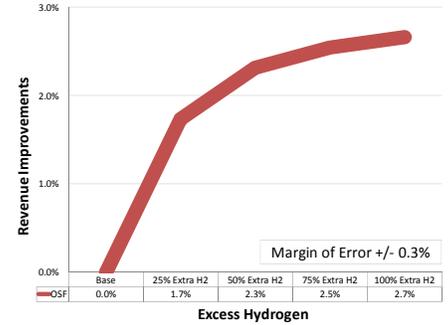
complete, running any number of informative performance studies on an existing facility is straightforward and fast.

And Upgrade studies truly reflect the performance of your plants because our proprietary method combines the best features of several tools. Upgrade was designed from the ground-up specifically to predict a plant's future revenues by calculating expected average production based on a plant's actual equipment configurations, reliability data, mass balances, operational rules, and tank logic.

### Results Summary

To evaluate the possible hydrogen plant capacities, sensitivity case models were run that varied the output. As illustrated in the chart below, revenue improvements generate a curve of diminishing returns. If PSC sells for \$100 per barrel, a 25% capacity plant generates \$28 million in additional revenue, and a 50% plant generates \$37 million.

Chart 1 – Diminishing Returns

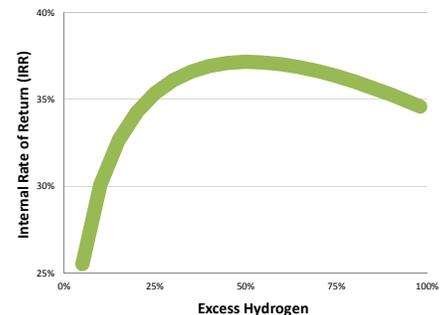


### Maximize Return on Investment

Calculating return on investment (ROI), requires both the expected revenue improvements and capital costs. Since we now have a plot of the expected revenues (Chart 1), we plot internal rate of return (IRR) against plant capacity (Chart 2) to find the maximum ROI, if we assume the following schedule of Total Installed Costs (TICs, in \$millions).

Cap.	25%	50%	75%	100%
TIC	\$80	\$100	\$115	\$125

Chart 2 – 50% Cap. Yields Max IRR of 37%



Now that Upgrade can more accurately predict revenue improvements from capital projects, our clients can allocate capital with confidence and maximize their expected ROI like never before.